# Climate, Weather and Water Science

Earth System Research Laboratory

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## Diagnosing Time Scales of Atmospheric Moisture Transport

# How does atmospheric variability on different time scales affect moisture transport?

- Synoptic scale
  - Extreme precipitation events (atmospheric rivers)
- Short-term climate
  - Droughts
- Long-term trends in hydrological cycle
  - Interaction with secular trends in tropical SST (e.g., Compo and Sardeshmukh 2009)

# Atmospheric Moisture Budget

$$\frac{\partial w}{\partial t} + \nabla \cdot \mathbf{Q} = E - P$$

$w$ = precipitable water ($\langle q \rangle$)
$\mathbf{Q}$ = vertically integrated moisture flux = $\langle \mathbf{v}q \rangle$
$\langle\rangle$ = mass-weighted vertical integral
$q$ = specific humidity
$E$ = surface evapotranspiration
$P$ = precipitation

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To explore moisture transport by different time scales, define

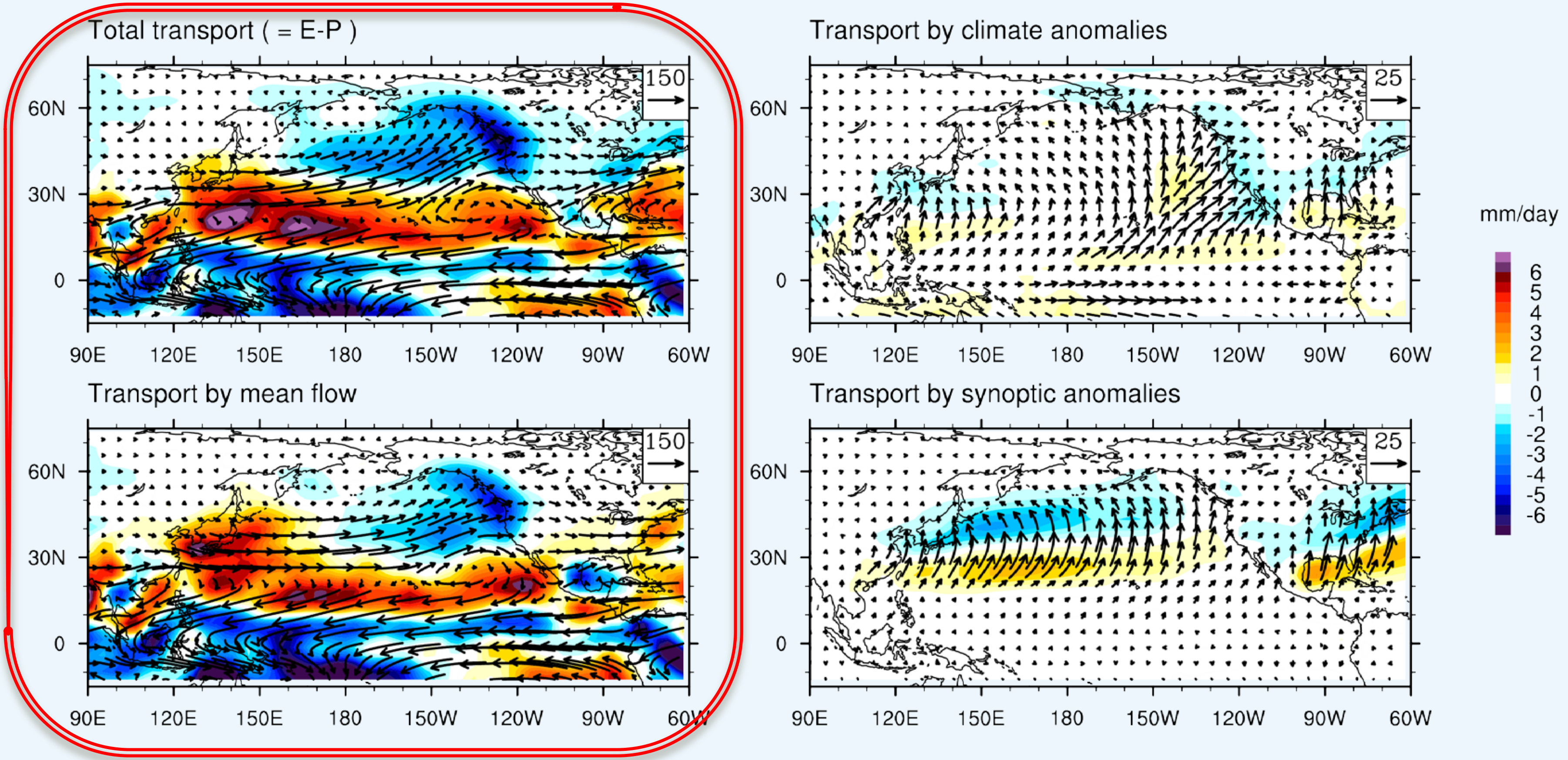
| $x$ | $=$ | $\overline{x}$ | $+$ | $x^l$ | $+$ | $x^h$ |
|---|---|---|---|---|---|---|
| total | = | longterm mean (1968-2007) | + | climate anomaly (periods>10 days) | + | synoptic anomaly (periods <10 days) |

Since $\partial \overline{w} / \partial t = 0$, the **mean moisture budget** is a balance between moisture flux divergence and the water source/sink:

$\boxed{\nabla \cdot \overline{\mathbf{Q}} = (\overline{E} - \overline{P})}$ where $\boxed{\overline{\mathbf{Q}} = \overline{\mathbf{v}}\overline{q} + \overline{\mathbf{v}^l q^l} + \overline{\mathbf{v}^h q^h}}$

# Wintertime Moisture Transport (1968-2007)

$\overline{\mathbf{Q}}$ = vectors; $\nabla \cdot \overline{\mathbf{Q}}$ = shading




**Mean moisture transport is mostly due to transport by the mean flow** (flux in left panels is 6x right panels)

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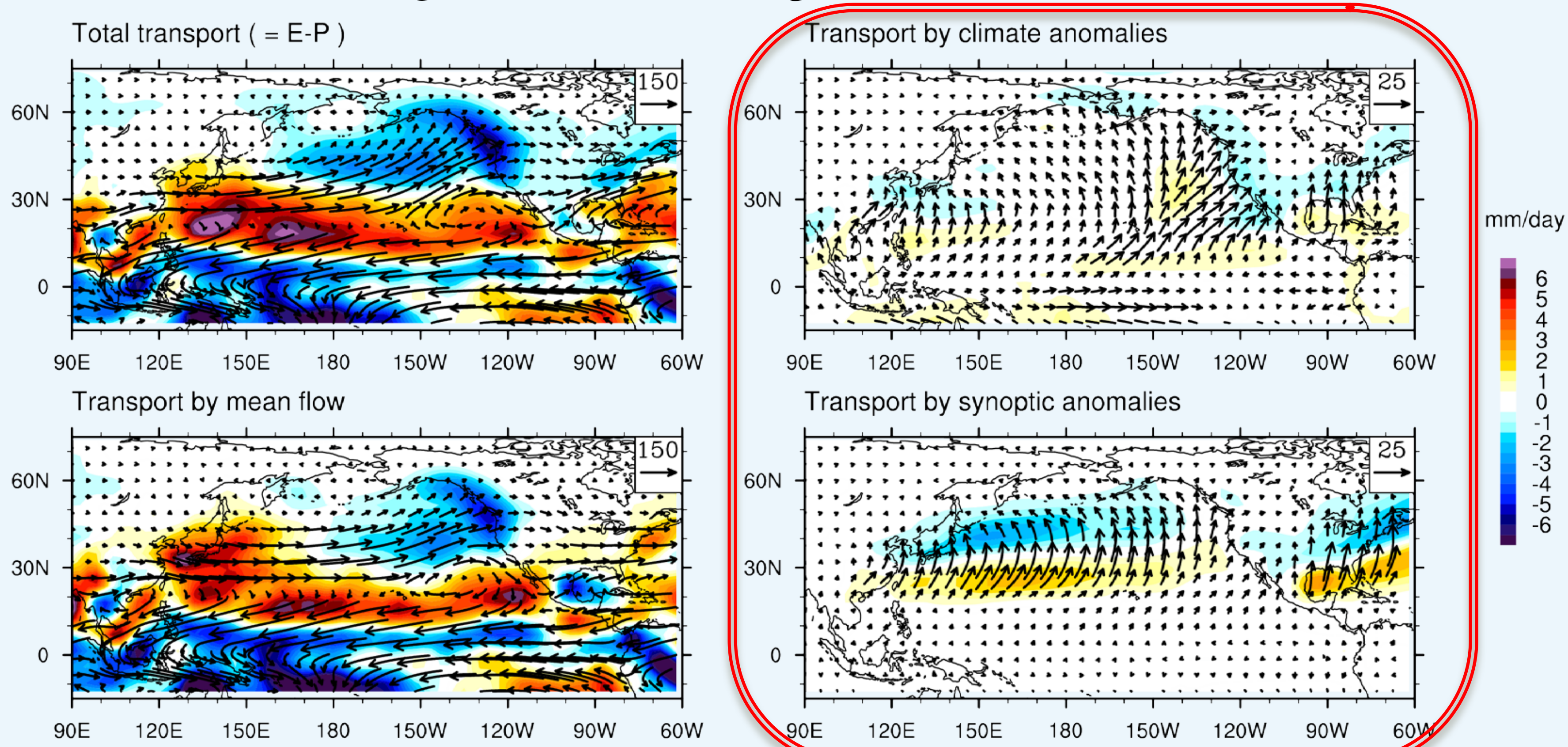


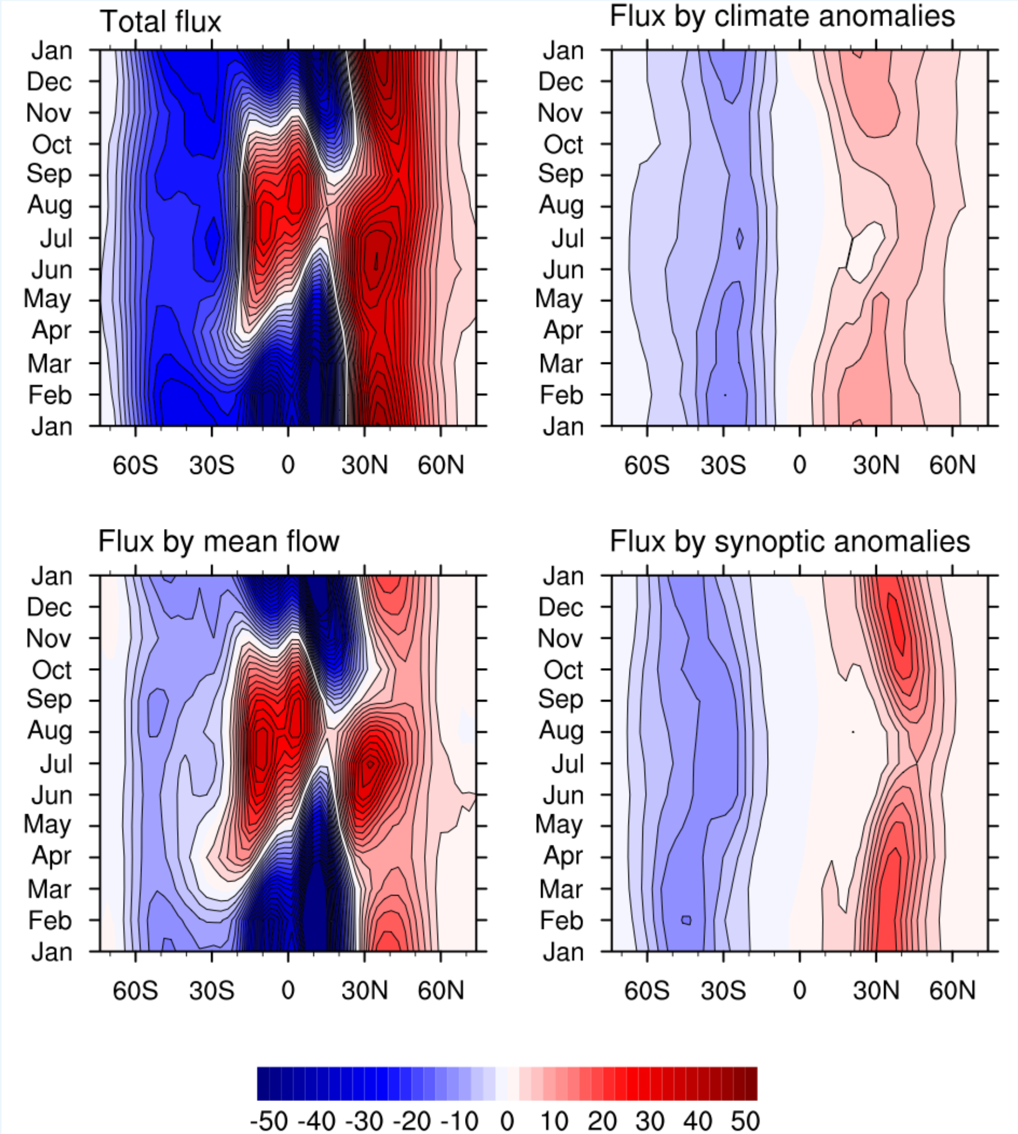

Transport by synoptic anomalies is generally greater than transport by climate anomalies, except along west coast


CIRES
NOAA

# Seasonal cycle of **meridional** moisture transport averaged in the Pacific sector (120E-120W)

<u>Tropics and subtropics:</u>
Meridional moisture flux dominated by transport by mean flow

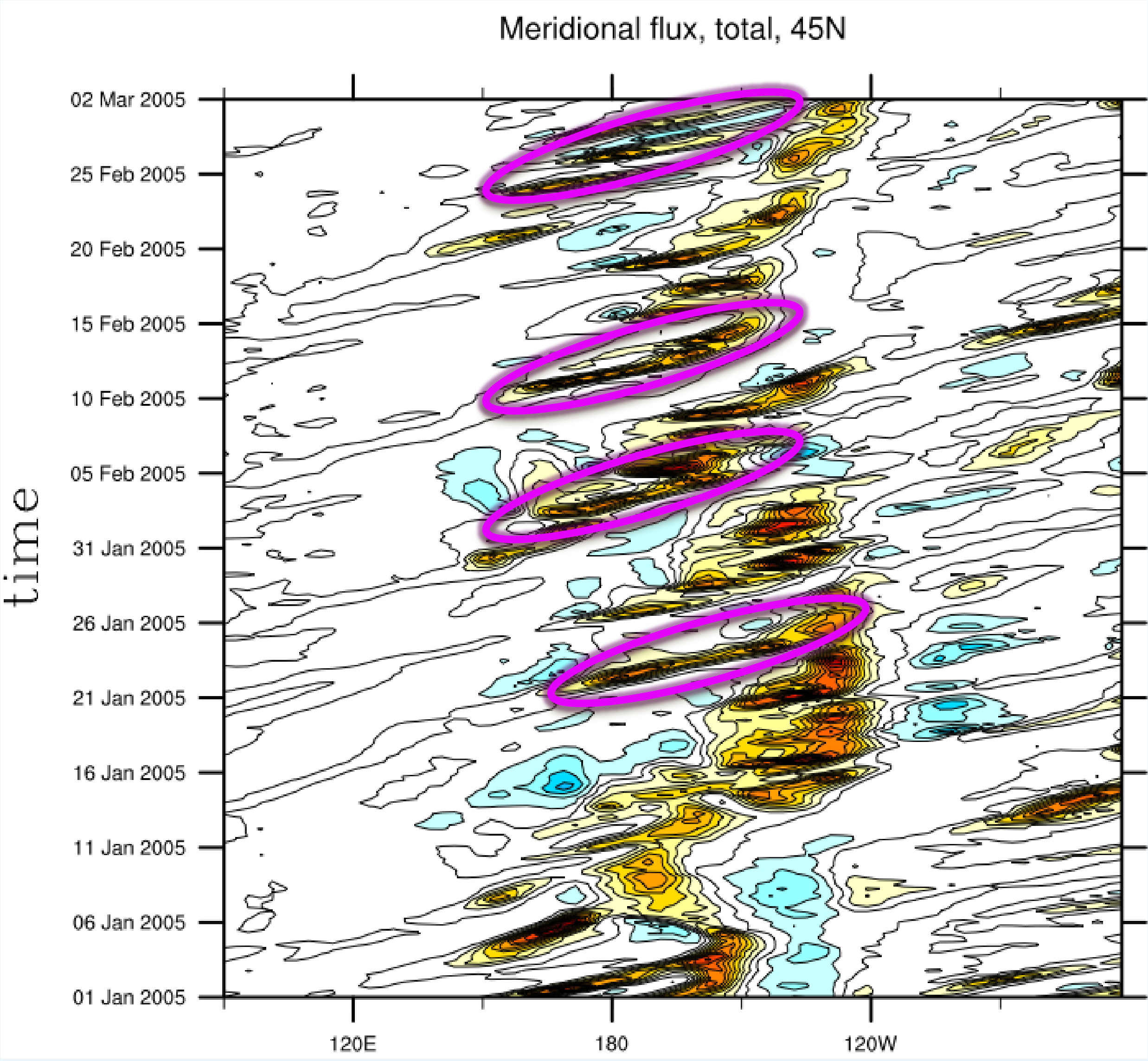
<u>Midlatitudes:</u>
**Meridional flux by synoptic anomalies equivalent to (or greater than) meridional flux by mean flow**!



# Meridional moisture transport by synoptic anomalies is important

Note that over this 2-month period (JF 2005), most flux occurs in fairly narrow meridional bands, termed **atmospheric rivers**.

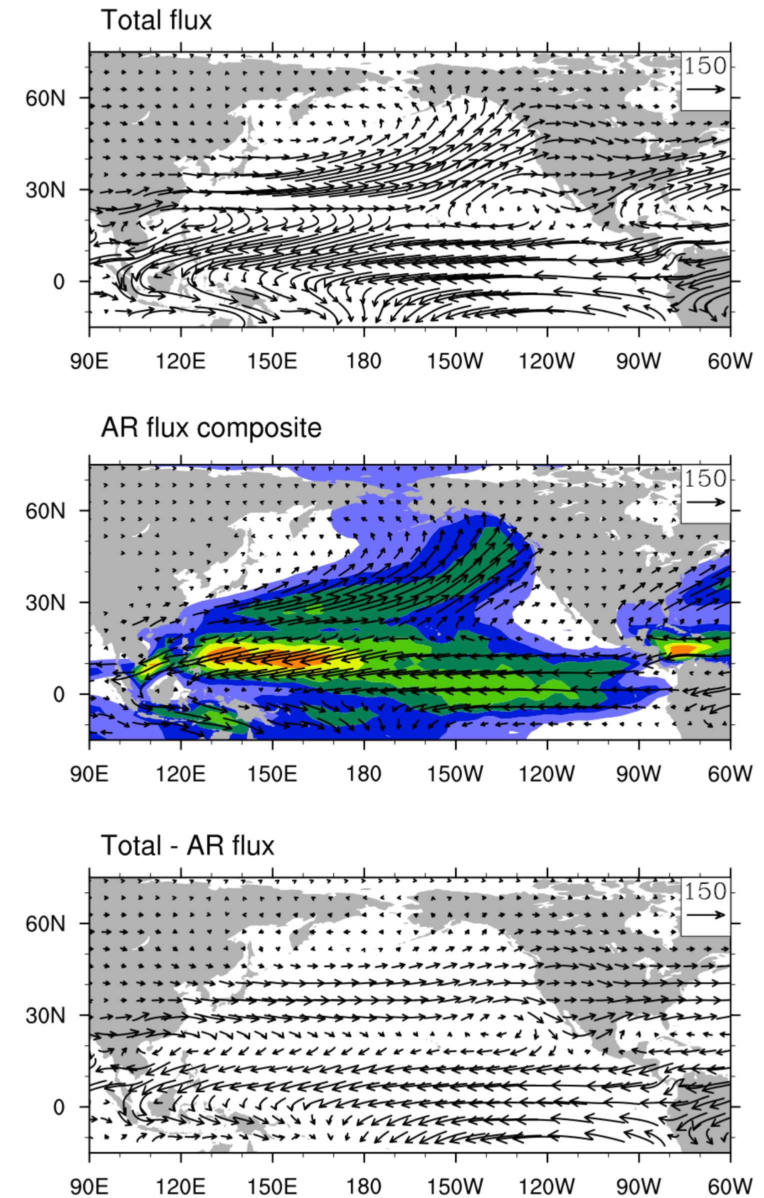
**This is a general result.**



# Moisture transport is dominated by atmospheric river conditions

**Total moisture flux**
compared to
**moisture flux composited by atmospheric river criterion**

Shading in middle panel indicates the frequency of occurrence of atmospheric river conditions (green>30%)



# Conclusions

- Mean moisture budget is primarily a balance between moisture transport by the mean flow and mean moisture source/sinks
- However, synoptic variability drives about half of the *extratropical meridional* mean moisture transport
  - Transport is focused within “atmospheric rivers”
- This approach also useful for moisture budgets of synoptic and climate variability, including trend
  - In particular, do other reanalyses (ERA40, MERRA, CFSRR) and climate models look like this?